

REMARKS

This is intended as a full and complete response to the Office Action dated April 21, 2005, having a shortened statutory period for response set to expire on July 21, 2006. Please reconsider the claims pending in the application for reasons discussed below.

Claims 1, 3-12, 14-19, and 21-26 remain pending in the application and are shown above. Claims 2, 13, and 20 have been canceled by Applicants. Claims 1-26 stand rejected by the Examiner. Reconsideration of the rejected claims is requested for reasons presented below.

Claims 1, 12, and 19 are objected to because of the phrase "cyclical deposition process." The Examiner asserts that a "cyclical deposition process" can be interpreted as repeating the process with another wafer in the same chamber. While Applicants disagree with the Examiner's interpretation of the phrase "cyclical deposition process," in order to expedite prosecution, Applicants have amended claims 1, 12, and 19 to clarify that the cyclical deposition process as claimed comprises alternately pulsing compounds, as recited in canceled dependent claims 2, 13, and 20. Applicants have amended claims 3-12, 14-17, 19, and 21-26 as to matters of form. Applicants submit that the changes made herein do not introduce new matter. Applicants respectfully request withdrawal of the objection to claims 1, 12, and 19.

Claims 1, 10-12, and 18 are rejected under 35 U.S.C. § 102(e) as being anticipated by *Wang et al.* (U.S. Patent No. 6,573,179). Applicants note that, as amended, claims 1 and 10-11 recite a method that comprises depositing a refractory metal nitride cap layer by a cyclical deposition process comprising alternately pulsing a metal-containing compound and a nitrogen-containing compound. Amended claims 12 and 18 recite a method that comprises depositing a cap layer comprising tantalum nitride by a cyclical deposition process comprising alternately pulsing a tantalum-containing compound and a nitrogen-containing compound. Applicants respectfully submit that *Wang et al.* does not teach or suggest alternately pulsing compounds to deposit a cap layer.

Thus, *Wang et al.* does not teach, show, or suggest a method for forming a cap layer, comprising depositing a barrier layer in a feature in a dielectric layer of a substrate, filling the feature with a metal-containing layer, planarizing the substrate, and depositing a refractory metal nitride cap layer on the substrate by a cyclical deposition process comprising alternately pulsing a metal-containing compound and a nitrogen-containing compound to deposit the refractory metal nitride cap layer, as recited in claim 1. Applicants respectfully request withdrawal of the rejection of claim 1 and of claims 10-11, which depend thereon.

Furthermore, *Wang et al.* does not teach, show, or suggest a method for processing a substrate, comprising depositing a barrier layer in a feature in a dielectric layer of a substrate, filling the feature with a metal-containing layer, planarizing the substrate, depositing a cap layer comprising tantalum nitride on the substrate by a cyclical deposition process comprising alternately pulsing a tantalum-containing compound and a nitrogen-containing compound to deposit the cap layer, and depositing an etch stop layer on the cap layer, as recited in claim 12. Applicants respectfully request withdrawal of the rejection of claim 12 and of claim 18, which depends thereon.

Claims 2-9 and 13-17 are rejected under 35 U.S.C. § 103(a) as being unpatentable over *Wang et al.* in view of *Gates et al.* (U.S. Patent No. 6,203,613). The Examiner acknowledges that *Wang et al.* fails to teach alternately pulsing a nitrogen-containing compound and a metal-containing compound or a tantalum-containing compound to deposit a cap layer. The Examiner states that *Gates et al.* discloses forming a refractory metal nitride layer by alternately pulsing compounds and asserts that it would have been obvious to combine the teachings of *Wang et al.* and *Gates et al.* to enable the deposition of a cap layer by alternating pulsing compounds, as one of ordinary skill in the art would have been motivated to look for alternative suitable methods for performing the cap deposition. Applicants respectfully traverse the rejection.

Wang et al. describes selectively depositing a barrier layer on a filled interconnect and not on an adjacent insulating layer to promote adhesion of the barrier layer material to the interconnect (abstract, column 4, lines 58-64, Figure 3). *Gates et al.* describes a method of atomic layer deposition of metal nitride films that may be used

as metal nitride barrier layers and shows a metal nitride barrier layer that conformally covers the etched features of a dielectric layer that define an interconnect before it is filled (Figure 1B, column 10, lines 27-31). However, Applicants respectfully submit that *Gates et al.* does not teach, suggest, or provide a reasonable expectation of success for using the atomic layer deposition process described therein to form *Wang et al.*'s barrier layer which is selectively deposited on a filled interconnect and not on an adjacent insulating layer. Applicants further submit that the combination of *Wang et al.* and *Gates et al.* does not teach, suggest, or provide a reasonable expectation of success for using the atomic layer deposition process described therein to selectively deposit a layer on a filled interconnect and not on an adjacent insulating layer.

Thus, *Wang et al.* in view of *Gates et al.* does not teach, show, or suggest a method for forming a cap layer, comprising depositing a barrier layer in a feature in a dielectric layer of a substrate, filling the feature with a metal-containing layer, planarizing the substrate, and depositing a refractory metal nitride cap layer on the substrate by a cyclical deposition process comprising alternately pulsing a metal-containing compound and a nitrogen-containing compound to deposit the refractory metal nitride cap layer, as recited in amended claim 1, which includes the limitations of canceled claim 2. Applicants respectfully request allowance of claim 1 and withdrawal of the rejection of claims 3-9.

Furthermore, *Wang et al.* does not teach, show, or suggest a method for processing a substrate, comprising depositing a barrier layer in a feature in a dielectric layer of a substrate, filling the feature with a metal-containing layer, planarizing the substrate, depositing a cap layer comprising tantalum nitride on the substrate by a cyclical deposition process comprising alternately pulsing a tantalum-containing compound and a nitrogen-containing compound to deposit the cap layer, and depositing an etch stop layer on the cap layer, as recited in amended claim 12, which includes the limitations of canceled claim 13. Applicants respectfully request allowance of claim 12 and withdrawal of the rejection of claims 13-17.

Claims 19 and 26 are rejected under 35 U.S.C. § 103(a) as being unpatentable over *Naik et al.* (U.S. Patent No. 6,204,168) in view of *Yang et al.* (U.S. Patent No. 6,734,559). Applicants note that, as amended, claims 19 and 26 recite a method that

comprises depositing a refractory metal nitride cap layer by a cyclical deposition process comprising alternately pulsing a metal-containing compound and a nitrogen-containing compound. Applicants submit that *Naik et al.* in view of *Yang et al.* does not teach or suggest alternately pulsing compounds to deposit a cap layer. Thus, *Naik et al.* in view of *Yang et al.* does not teach or suggest all of the limitations of claims 19 and 26. Applicants respectfully request withdrawal of the rejection of claims 19 and 26.

Claims 20-25 are rejected under 35 U.S.C. § 103(a) as being unpatentable over *Naik et al.* in view of *Yang et al.* and *Gates et al.* The Examiner states that *Naik et al.* in view of *Yang et al.* fails to teach alternately pulsing a metal-containing compound and a nitrogen-containing compound to deposit the cap layer. The Examiner asserts that it would have been obvious to combine the teachings of *Yang et al.* and *Gates et al.* to enable the deposition of a cap layer by alternating pulsing compounds, as one of ordinary skill in the art would have been motivated to look for alternative suitable methods for performing the cap deposition. Applicants respectfully traverse the rejection.

Applicants note that as amended, claim 19 clarifies that the cap layer is deposited on a planarized metal-containing layer and a planarized dielectric film. *Yang et al.* describes a method of forming a self-aligned semiconductor interconnect barrier by etching a recess in a channel conductor (a metal), depositing the barrier material, and removing the barrier material outside the channel (Figures 3-5). Thus, the barrier material of *Yang et al.* is deposited on an etched metal-containing layer rather than a planarized metal-containing layer. *Gates et al.* describes a method of atomic layer deposition of metal nitride films but does not teach or suggest depositing the metal nitride films as a cap layer on a planarized metal-containing layer and a planarized dielectric film of a dual damascene structure. *Naik et al.* discloses a method of forming a dual damascene structure but does not describe or suggest forming a cap layer by a cyclical deposition process on the metal interconnect of the dual damascene structure. Instead, *Naik et al.* describes planarizing and passivating the metal interconnect using a hydrogen-based chemistry and a silicon nitride deposition of a passivation layer (column 7, lines 14-17). Applicants respectfully submit that *Yang et al.* and *Naik et al.*, individually or in combination, do not suggest, motivate, or provide a reasonable

expectation of success for replacing *Naik et al.*'s passivation process with *Yang et al.*'s barrier layer deposited by the atomic layer deposition process of *Gates et al.*, as neither *Yang et al.* nor *Gates et al.* teaches or suggests that the barrier layers provided therein can be used to passivate a metal interconnect or that depositing a barrier layer by a cyclical deposition process can be used to passivate a metal interconnect. Applicants further submit that adding *Yang et al.*'s barrier layer deposited by the atomic layer deposition process of *Gates et al.* as a cap layer to the structure of *Naik et al.* does not provide or suggest all of the limitations of claim 19, as *Naik et al.*, *Yang et al.*, and *Gates et al.*, individually or in combination, do not teach or suggest depositing metal nitride films as a cap layer on a planarized metal-containing layer and a planarized dielectric film of a dual damascene structure.

Thus, *Naik et al.* in view of *Yang et al.* and *Gates et al.* does not teach, show, or suggest a method of forming a dual damascene structure, comprising depositing a first dielectric film on a substrate, depositing an etch stop on the first dielectric film, pattern etching the etch stop to define a vertical interconnect opening and expose the first dielectric film, depositing a second dielectric film on the etch stop and the exposed first dielectric film, pattern etching the second dielectric film to define a horizontal interconnect and continuing to etch the exposed first dielectric film to define the vertical interconnect, depositing a barrier layer on the substrate, depositing a metal-containing layer on the substrate to fill the vertical interconnect and the horizontal interconnect, planarizing the metal-containing layer and the second dielectric film, depositing a refractory metal nitride cap layer on the planarized metal-containing layer and the planarized second dielectric film by a cyclical deposition process comprising alternately pulsing a metal-containing compound and a nitrogen-containing compound to deposit the refractory metal nitride cap layer, and depositing an etch stop layer on the refractory metal nitride cap layer, as recited in claim 19. Applicants respectfully request allowance of claim 19 and withdrawal of the rejection of claims 20-26.

In conclusion, the references cited by the Examiner, alone or in combination, do not teach, show, or suggest the invention as claimed.

The secondary references made of record are noted. However, it is believed that the secondary references are no more pertinent to Applicants' disclosure than the

primary references cited in the office action. Therefore, Applicants believe that a detailed discussion of the secondary references is not necessary for a full and complete response to this office action.

Having addressed all issues set out in the office action, Applicants respectfully submit that the claims are in condition for allowance and respectfully request that the claims be allowed.

Respectfully submitted,



Keith M. Tackett
Registration No. 32,008
PATTERSON & SHERIDAN, L.L.P.
3040 Post Oak Blvd. Suite 1500
Houston, TX 77056
Telephone: (713) 623-4844
Facsimile: (713) 623-4846
Attorney for Applicant(s)